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5G: MIMO BDMA SYSTEM TRENDS AND TECHNOLOGY

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ABSTRACT

Beam Division Multiple access (BDMA) is the last technique came to create the fifth-generation (5G) and solving the problem in the fourth generation (4G). In which base station (BS) allocates private beam to the mobile station (MS) in the system, to increase the capacity and bandwidth of system. For that antenna beam is divided according to the speed and location of mobile stations. In mobile wireless communication the important thing is how to increased limited frequency of the system, improve data rate and good quality of services for user etc. This paper presents information about BDMA and explains the different technologies, and which we want to making future mobile with more powerful and more in demand. Useful thing in BDMA technique is the large number of users to connect at the same time by direction of orthogonal beam from BS by giving multiple access to MS, and increasing the ability of system to be established very big channel. Direction of antenna beam goes off the desired location of MS, and void are placed in undesired direction depend on work environment.

1. INTRODUCTION.

The various multiple access techniques is growing at a rapid pace for multiple user to usage efficient like is Time Division Multiple Access (TDMA), Frequency Division Multiple Access (FDMA)... Etc. In Telecommunication system, the limitation oftime and frequency are divided to be used by subscribers (user) also capacity is limited

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because depend on giving frequency and time. Now we demand a development technique utilize other resources to increase the ability of system. So the thought of Koreans in seeking for finding anew access technique Known as BDMA for next generation (fifth generation) of mobile wireless communication system. Short term of BDMA is Beam Division Multiple Access.Next generation utilize (BDMA) that enable to transmit data rate greater than 100Mbps for one square kilometer to million Internetof things. 5G includes advantages such it is the strongest and high demanding in the near future. Founding 5G technology have come to existence high resolution for moving mobile users, higher data rates and Quality of Service (QoS), high bandwidth. Big challenge in the telecommunication field will be to how increase capacity of system and quality of service within the limited frequency spectrum, in 5g will be frequency band 3-300GHz and the Bandwidth of 1 Giga bit per second (Gbps) or highest from that[1]. Mobile wireless communication system based on BDMA has to support better quality service to a lots of subscribers. Fifth generation (5G) telecommunications network provided typical solutions for thecommon problems in the fourth generation (4G). Add to that we can increase the capacity and reliability, in this technology also we can reduce bit error rate [2].

2. Beam Division Multiple Access and Fifth Generation.

The main aim of (mobile network wireless communication system) has to availability high quality of service to a big number of user via different beams by select user without interference of beams with others and affordable cost. Beam Division Multiple Access (BDMA) is foreseen as the latest multiple access technology for next or fifth generation (5G) of wireless communication [3]. What meant by the beam division? It is dividing of beam according to environment will towards to desired direction and nulls are placed in undesired direction. In BDMA available beam can be divided in to 3D and improve the capacity of system as shown in figure 1. Multiple accesses to channel depend on multiple access technology. A channel represents a resources of data that enable the user (mobile station) to connect with other user in network. Many user can be share a large data from their resources by using a finite spectrum in multiple access. Multiple access is desirable to allow the subscriber to send information at the same time from mobile station (MS) to base station (BS) while receiving information from BS, in wireless communication system.

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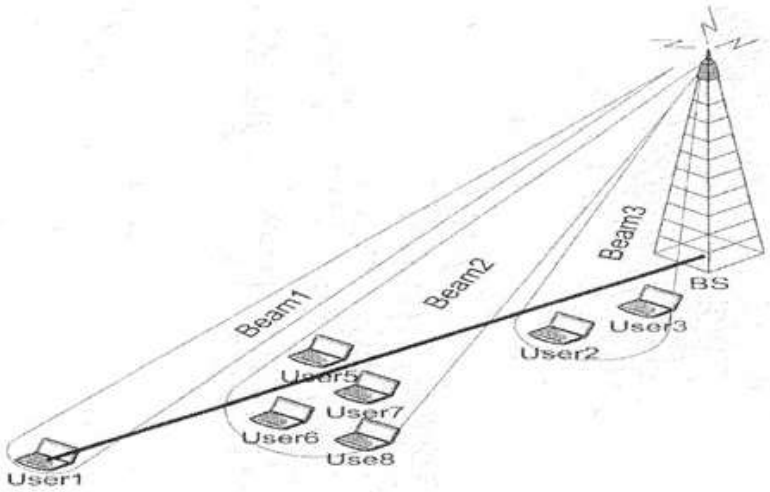

Figure 1: Beam Division Multiple Access [4]

From (1G) to the(2.5G) and from (3G) to (5G) Communications system improved dramatically with a significant improvement in the transfer and receipt of data. Because of the huge volume of data and sources and increasing numbers of subscribers, it has become necessary to develop communication system and meet the real requirements of users. 5G (5th generation mobile networks or 5th generation wireless systems) Designed for the future of mobile telecommunications standards, and it is supposed to outperform significantly on the current 4G standards. Due to the frequency band of 5G will be 3-300GHz and the bandwidth more than 1Gbps, so that will become more capacity and quality of service than previous generations[5]. 5G provides many features such as photo gallery, messenger, and multimedia applications, telephony, camera, etc.Add to high speed and capacity, and low in cost (per bit). All this features supports, video streaming, interactive Internet, and other broadband services. This technology has a great future because it can handle best technologies such as BDMA. World market willacquires by the 5G technology [5].

The major differences, between present generations and expected 5G techniques as shown in figure 2 are:

a. High data rates up to 1Gbps.

b. A large range of signal coverage.

c. Reduce the battery consumption.

d. Different and multiple paths for data transmission at the same time.

e. Worldwide wireless web (wwww).

f. More security.

g. Supposed to have no effect on human health.

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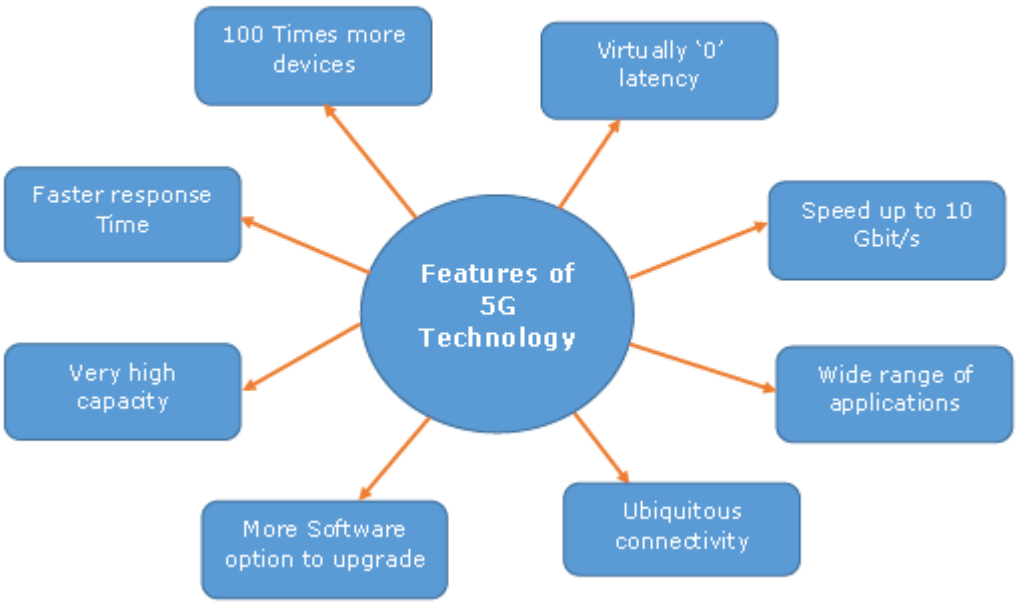

Figure 2: Feature of 5G Technology [6]

3. Analysis Methods of 5G technology.

3.1 5G millimeter wave technology.

An increasing need to larger bandwidth arises because the huge growth of large number of user of mobile. As it is well known the bandwidth is limited in available frequency spectrum, and which is less the (mm) wave band. So it was discovered wave band as mobile frequency spectrum by operators to be able to support larger bandwidth. But the problem remains in the noise, penetrate walls, some objects in buildings, and rain. After taking into consideration all these factors mm wave can will become stronger and betteras shown in figure 3. Note that these waves are called 5G millimeter wave [7].

Advantages of 5G millimeter wave:

- More number of subscribers can be accommodated due to provides larger bandwidth
- More favorable for smaller cell due to less bandwidth in millimeter range.
- Coverage is not limited to line of sight (LOS).

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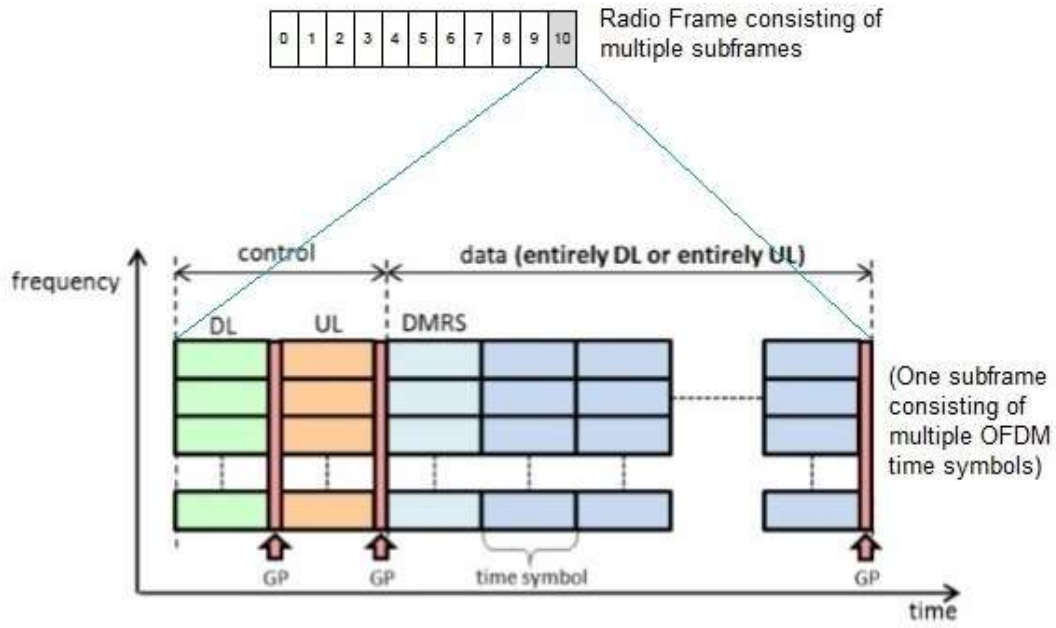

Figure 3: 5G millimeter wave frame and sub frame [7]

Disadvantages of 5G mm wave:

• Millimeter wave goes through different losses such as penetration, rain attenuation etc. Moreover path loss at mm is proportional to square of the frequency.
• Loss in mm wave frequencies due to Foliage.
• Supports only LOS (Line of Sight) propagation. Hence coverage is limited to LOS.
• Loss of energy because of higher at millimeter wave due to more number of radio frequency modules due to large number of antennas [7].

3.2Mobile Ad-hoc Networks (MANETs).

Mobile Ad Hoc Network (MANET) It is a connecting multiple nodes or terminals with some in a way wireless communications without the service of any controlling or microcontroller. These nodes can be able to communicate and transfer information away from the use of any existing fixed network infrastructure [8]. Mobile computing in the field of computers and communications it has become a high-level Due to the rapid development of Computing. (MANET) it is a completely wireless connection, and it's done by nodes at each calculator or Mobile, and usually take the Dynamic form with a limited bandwidth. The most prominent challenges in Mobile ad hoc networks is the process of guiding thedata packets from end to end (source to destination), Where it will be difficult in mobile ad hoc networks because of the continued movement and the absence of centralized control over all nodes (Mobile Station) [9] as shown in figure 5. Types of MANET as shown in figure 4:

1. VANETs. Communication between vehicles, also between vehicles and equipment on the Roadsides can be use VANETs.
2. Mobile nodes and stable Internet-nodes can be linked by Internet Based Mobile Ad-hoc Networks (I MANET)[10].

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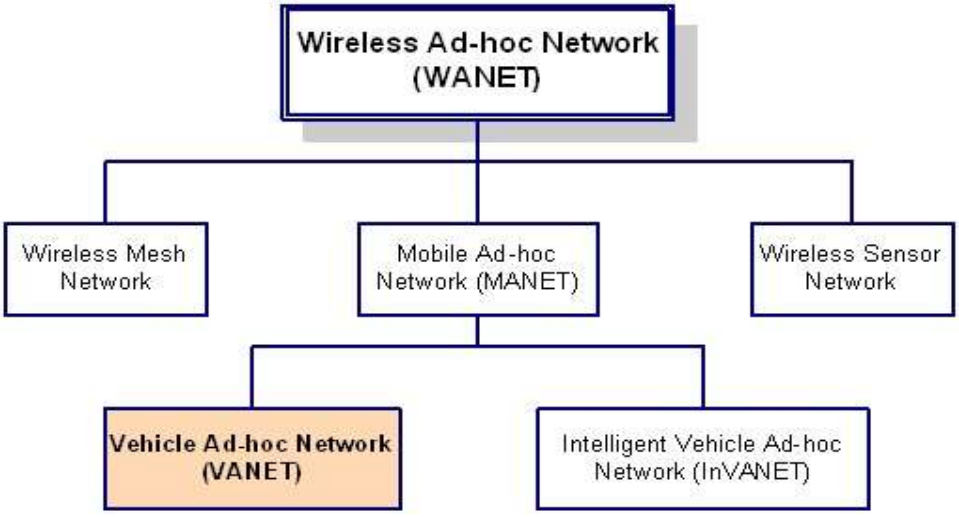

Figure 4: type of networks normal ad hoc [10].

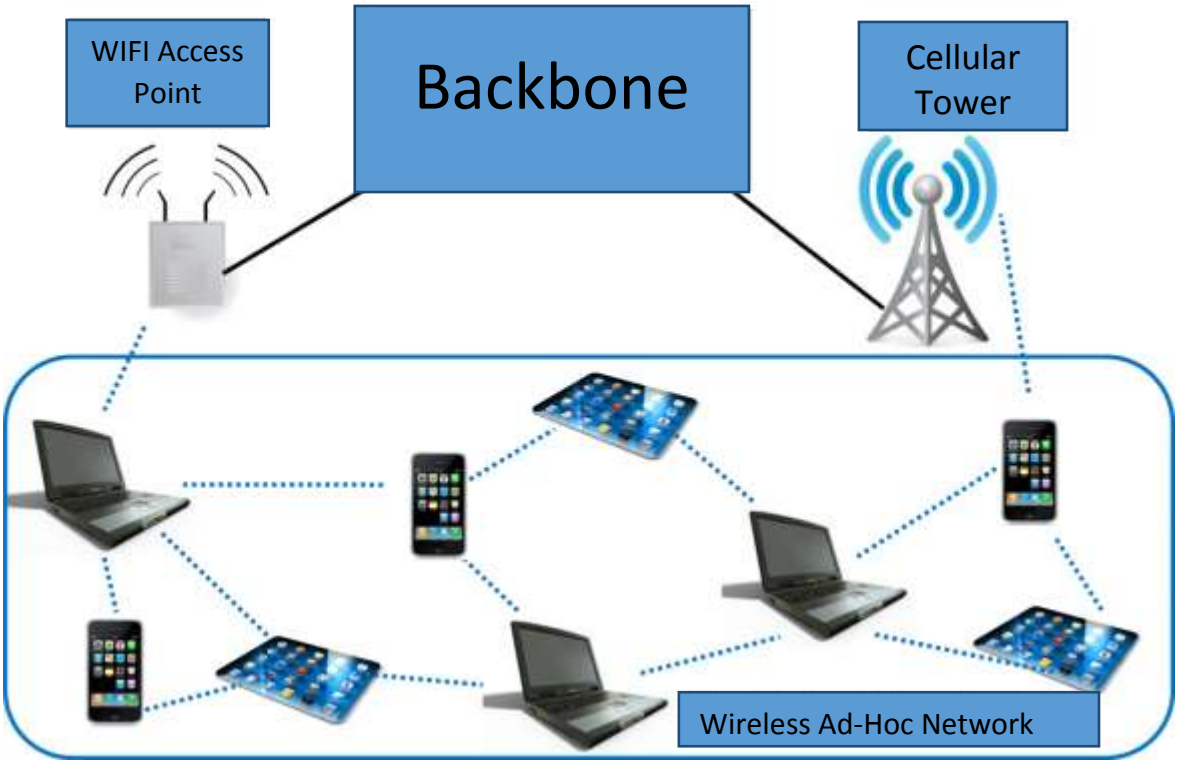

Figure 5: Ad-hoc network [7].

4. BEAM DIVISION MULTIPLE ACCESS technology

The main goal of mobile communication systems is to provide good services to a larger number of mobile users at lower costs. To provide good services, three are major multiple access techniques FDMA, TDMA and CDMA used to share the available bandwidth in a

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wireless communication system as shown in figure 6. This techniques can be illustrated as follows:

1. Frequency Division Multiple Access (FDMA) – Each user have a dedicated allocation of one or several frequency bands in this technique.
2. Time Division Multiple Access (TDMA) - Number of users can share the same frequency channel by partition the signal into slots of time in this technique.
3. The codes that provides the mobile stations can be separates calls by using code Division Multiple Access (CDMA) technique.
4. Enhance resource of system frequency can be done through division and allocation by using Orthogonal Frequency Division Multiple Access (OFDMA).

In future, due to the increasing in number of user (MS) and the volume of data to be transferred, the capacity of (wireless network communication system) required to increase [11].

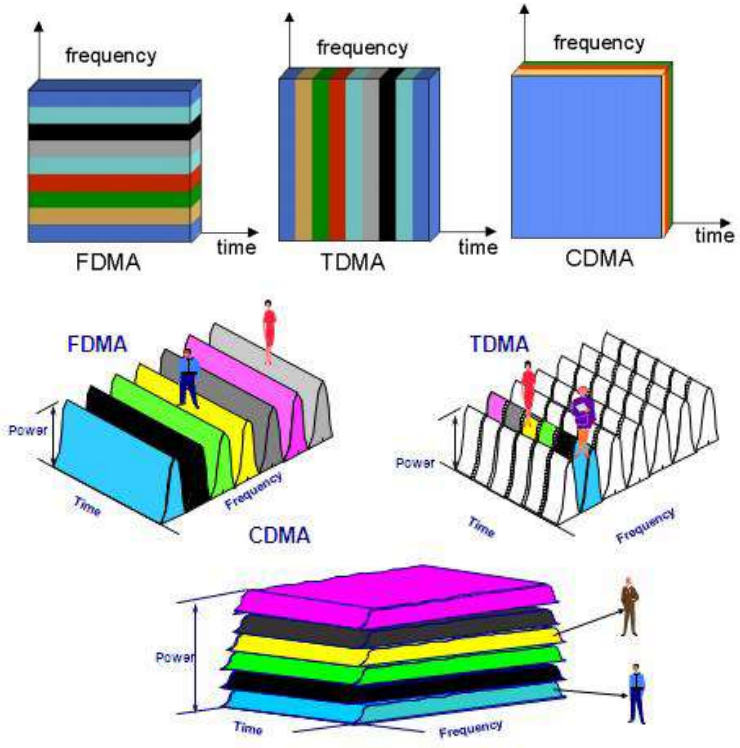

Figure 6: Multiple Access Technology [11]

5. Concept of BDMA Technology:

Due to the increasing subscribers' request to need a new technology which can meet their needs, such that it should improve the channel efficiency, data rate and provide quality in service. MIMO is one technology to develop solutions for this situation, it is able to provide the required performance using multiple transmitter and receiver antennas [10]. BDMA is the last technique in which an orthogonal beam is allocated to each mobile station. this orthogonal beam is allocated to every mobile station (MS) need to communication with base station (BS), The BDMA technique depend on time division multiple access with slow

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frequency hopping (SFH-TDMA) and orthogonal frequency division multiplex (OFDM)[10]. division of beam can be done through BS based on locations and number of MS, thereby significantly increases the capacity of the system since BS can be transmit single or multiple beam at the same time and without interference to provide multiple access of system [11]. When MS and a BS can be in Line of Sight an (LOS) state BS will transmit single beam, But When MS are positioned at different angles compared to the BS, and the BS will transmit beams at different angles to transmit data at the same time. BDMA uses phased antenna array, beam forming technique to produce dedicated beam and uses multiple beam for multiple access, in a new space division multiple access technique. When mobile stations are present at different positions or angles, each one of them are provided with a beam separately. If the mobile stations are in same location then they use a single beam, by using the available frequency - time for multiple accessesas shown in figure 7. The change in position, speed or direction of mobile station means change the number of beams, width and direction according to movements of mobile station [12].

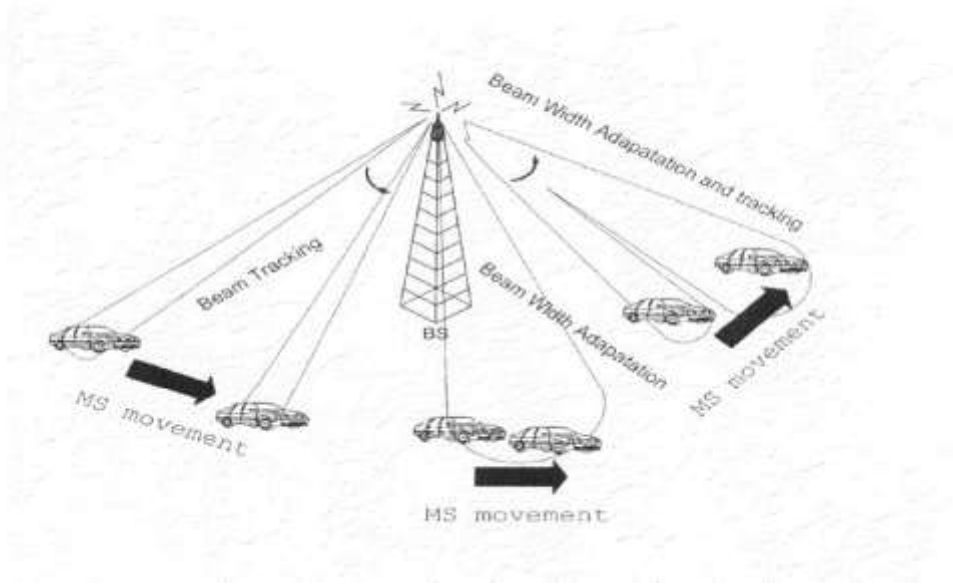

Figure 7: BDMA Technology [12]

The steps show us to set of connectionas shown in figure 8:

A. In the beginning, the positions of BS and MS unknown to both; the mobile stations must be discovering its location and moving speeds and the location of base station.

B. The mobile station transmit there moving speed and position to base station, and then BS determines the width and direction of downlink beam (DL).

C. Once, the direction and width of the DL is computed by mobile station, and transmits the uplink beam (UL) in the same direction.

D. Base station receiving the UL, after that the (uplink and downlink beam) should be updating to start of carrying data [12].

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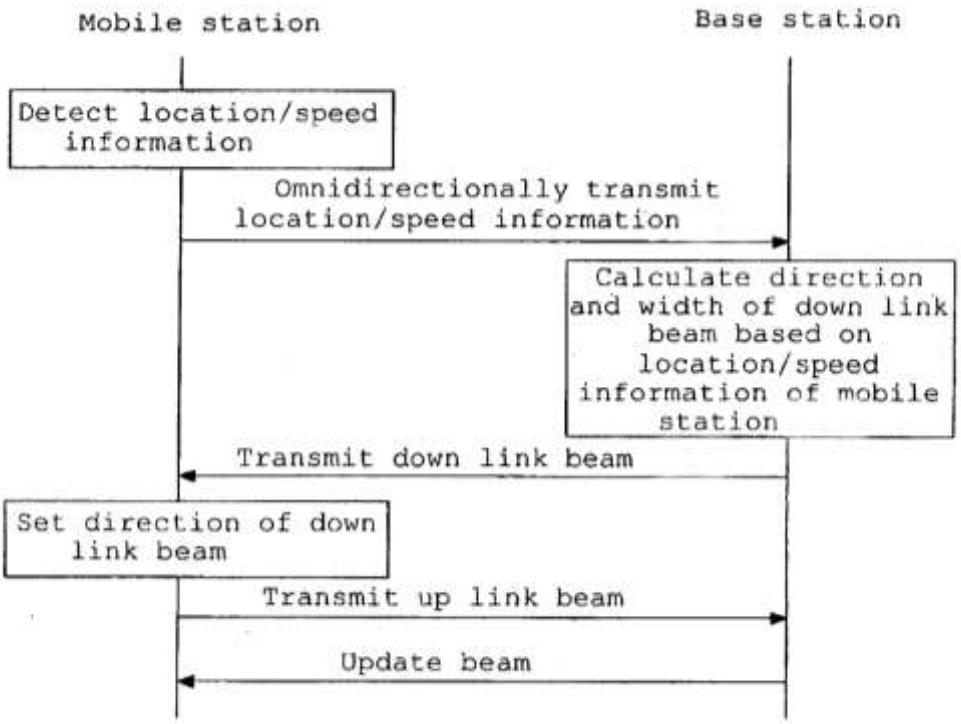

Figure 8: Step for set of connection between BS and MS[12]

6. MIMO-BDMA SYSTEM MODEL

Beam forming is a method used to configure the radiation from the antennas to the desired shape and the desired direction (mobile phone) Directed radiation empty for non-desirable trend. It used for direct data transfer and receipt of the signal between the base station and mobile station. There are basically two approaches:

1. Switched beam antenna: Generate a limited number of radiation patterns, which makes the RF signal and one is available each beam is possible. It has been compiled using the patterns of wireless network the simplest approach beam Switched compared with adaptive approach. This it provides a significant increase in Network capacity compared with the Conventional multi-directional antenna Systems or existing systems sector.

2. Adaptive Array Antenna: an infinite number of radiation patterns of use of adaptive air Matrix is one of the areas that promise further improve Wireless systems and provide improved capability Safety by the capabilities of the site's position.

This is Matrices can be used to reject any interference as shown in figure 9by:

* altering spatial position of the site through the trend.
* ending measurements and the development and improvement.
* Channel models through the corner of Canal and arrival.
* Sounding measurements.

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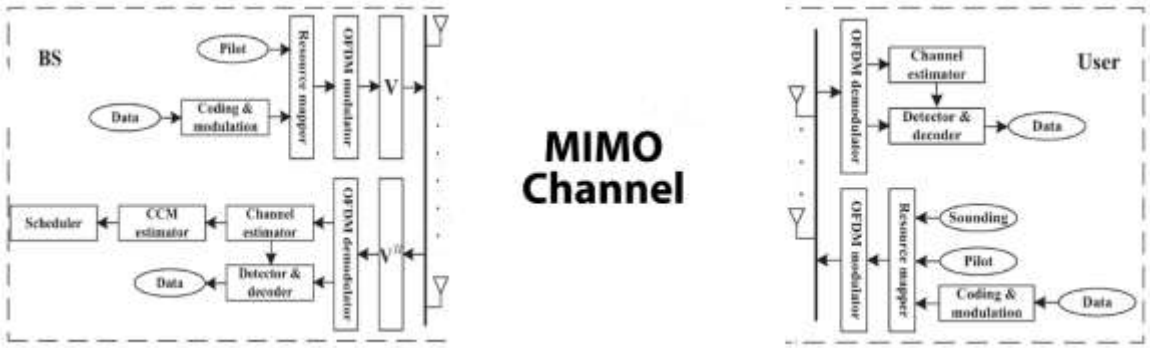

Figure 9:MIMO-BDMA SYSTEM MODEL[13]

Tracking of mobile phone by this system can be done by constantly directing the (main beam) toward the user, and the formation of null values in the orientations Interference signal. Ray turned like Systems, it also includes arrays. Typically, the received signal from each of the distributed elements of antenna it is multiplied by its weight. These signals it is combined to produce the output range. This complex is calculated by weights Complex adaptive algorithm, which is Pre-programmed digital signal processing the unit that manages the signal Emitted from the BS[3].

In this paper, we assume a channel model, which describes the spread between transmit array and receive array. Suppose that there are P physical paths between the (BS) and (MS), and the *p1th* path of the u user has an attenuation of *(ϕ^(p,u))* an angle of *(θ^(p,u))* with the transmit , and an angle of *(θ^(p,u))*with the Receive .Then N ×*M* physical MIMO channel matrix in the downlink linked with the *pth* path of the *uth* user is given by equationbelow:

$$[\boldsymbol{H}_{\boldsymbol{d}}^{\boldsymbol{p,u}}] = \mathbf{O}^{\boldsymbol{p,u}}\, \boldsymbol{exp}(-\boldsymbol{i2\pi D}^{(\boldsymbol{p,u})}/\boldsymbol{\gamma r}) * \boldsymbol{m}^{\boldsymbol{r}}(\boldsymbol{\theta}^{\boldsymbol{p,u}})\, \boldsymbol{m}_{\boldsymbol{t}}^{\boldsymbol{H}}(\boldsymbol{\phi}^{\boldsymbol{p,u}}) \quad (1)$$

Where *d* means downlink, $\boldsymbol{d}^{\boldsymbol{p,u}}$is the physical distance between transmit and receive of antenna along path *p*, and is the *γr* carrier wavelength. Added to that, $\boldsymbol{m}^{\boldsymbol{r}}(\theta) \in CN\times 1$ which obtain $||\boldsymbol{m}^{\boldsymbol{r}}(\theta)||_2 = 1$is the subscribeof the (antenna array).*θ*, and et$(\phi) \in CM\times 1$ which obtain *et(ϕ)_2* = 1 is the base station (BS) of the antenna array. The channel frequency is the equation below:

$$[H_d^{l,u}] = \sum_{p=1}^{P1} o^{p,u} \exp(-i2\pi D^{(p,u)}/\gamma r) * m^r(\theta^{p,u})\, m_t^H(\phi^{p,u}) \exp(-i2\pi l t^{(p,u)}) (2)$$

Where $t^{(p,u)}$is the (Spread delay)linked with the (*p*th path). We suppose that the uplink physical channel has the same parameters $(\theta^{p,u}, \phi^{p,u}, t^{(p,u)})$ as the downlink channel except for the carrier frequency and the initial phases Hence,uplink channel can be calculate[14] .

If we assume that users are quite far away from the BS such that the phases *2π 〖d〗^(p,u)/γr* are uniformly distributed on [0, 2π] and due to the uncorrelated scattering, it become mutually independent. Now, we have:

$$€\{o^{p,u} \exp(-i2\pi D^{(p,u)}/\gamma r)\} = 0 (3)$$

$$€\{o^{p,u} \exp(-i2\pi D^{(p,u)}/\gamma r)(o^{p',u'} \exp\left(-\frac{i2\pi D^{(p',u')}}{\gamma r}\right))^{*}\} = \beta^{p,u} £ \text{ (p-p', u-u')} (4)$$

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This assumption depend on the BS antennas are located much higher rooftops this means a lack of distractions in BS. Where *β^(p,u) = E {|o^(p,u)|2}* is the channel gain of path p [15].

$\lim_{M\to\infty} m_t^H(\phi) m_t$ (ŋ)= £ (*ϕ*- ŋ) (5)

For each user, when the sampling of $\theta^{N,u}$satisfies the condition

$(m_t^H(\theta^{N,u}) m_t(\theta^{N',u})) =$£ (*N-N* ')(6)

We can rewrite the channel matrix in (2) as

$H_d^{l,u}$= $\sum_{N=1}^{N1}\sum_{b1=1}^{b2}$[Ħ$_d^{l,u}$]N,b1$m^r(\theta^{N,u})m_t^H(\phi^{b1})$ = WuĦ$_d^{l,u}V^A$(7)

Where*V=[mt(ϕ1), mt(ϕ2), . . . , mt(ϕM)] ∈CM×M, andWuk=[mr(θ1,u),mr(θ2,u), . . . , er(θN,k)] ∈CN×N* is aidentity matrix. Note that, as the number of BS antennas *b2*tends to infinity,*V*becomes an asymptotically identity matrix. We call [Ħ$_d^{l,u}$]as the beam domain channel [14], we have the following equation:

[Ħ$_d^{l,u}$]N, b1≃ $\sum_{P\epsilon T(r,N)\cap T(t,b1)} o^{p,u}\exp(-i2\pi D^{(p,u)}/\gamma r)\ \exp(-i2\pi lt^{(p,u)})$(8)

Where $T^{(r,N)}$is the receiving angles for set of all paths, and $T^{(t,b1)}$is the transmit angle for set of paths.

So,number of columns in channel matrix $H_{u,l}^d$ is [15]:

Vec($H_{u,l}^d$)= $\sum_{N=1}^{N1}\sum_{b1=1}^{b2}$ 1{ [Ḧ$_{k,l}^d$]nmm_t^*(£m) ∗ $m^r(\Theta^{(p,u)})$ (9)

And calculate the full correlation matrix of$H_{u,l}^d$

Vec($H_{k,l}^d$)= $\sum_{n=1}^{N}\sum_{m=1}^{M}$ Ē{ [Ḧ$_{k,l}^d$]nm[Ḧ$_{k,l}^d$]$_{nm}^H$ * (m_t^*(£m) ∗ mr(Θn,k))(m_t^*(£m) ∗ mr(Θn,k))(10)

We can define the Eigen mode channel coupling matrices (CCM) as [16]:
$\Omega_{u,l}^d$=Ē{ Ḧ$_{k,l}^d$ʊ(Ḧ$_{k,l}^d$)*} (11)

We find that the Eigen mode CCM $\Omega_{u,£}^d$is likewise independent of sub-carriers. According to [17], the (UL) and (DL) statistical channelstate information (CSI) are usually reverse in both time-division duplex (TDD) and frequency-division duplex (FDD) systems. Thus, we can indicate the (UL) and (DL) CCMs as:

$\Omega_{u,l}^d = (\Omega_{u,l}^{u1})^T = \Omega_u$(12)

Whose elements can be approximated by [*Ωu*]*Nb1*≈ $\sum_{P\epsilon T(r,N)\cap T(t,b1)} \beta^{p,u}$ Note that the superscript *u1*denotes (UL).The received signal at the *uth* user in the *£th* OFDM subcarrier can be rewritten in the form

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$y_{u,l}^{d} = H_{u,l}^{d} I_{u,l}^{d} + n'_{u,l}$(13)

Where $I_{u,£}^{d} \in C_{M\times 1}$ is the signal meant for the uth. The received signal of uthuser in the lth sub-carrier can be as follows:

$\tilde{Y}_{u,l}^{d} = \ddot{H}_{u,l}^{d} \bar{I}_{u,l}^{d} + \sum_{i=1,i\neq u}^{k} \ddot{H}_{u,l}^{d} \bar{I}_{i,e}^{d} + \acute{n}_{u,l}$(14)

The 5G gave us through the use of technology BDMA a lot of advantages, the important one is the high speed in data transforming as compared with previous generation and the smart use of send data instead of Wi-Fi technology and losing in power and band, and this leads to increase in capacity and the number of user who can connect with the system, and keep the bandwidth from dispersion by allocating beam (packets of data) directly to the subscribers this allows us to send more data size whether video, audio, etc., this is the most important part of the idea of BDMA [18]. It should also be noted that BDMA reduce latency significantly compared to the fourth generation (4G) as well as previous generations. This make a revolution in communication and data transform. Add to that BDMA solve problem between cell overlapping and solve performance deterioration problems of subscriber at cell that occurring in a cellular system. Taking into consideration radiation efficiency of the antennas can be maximized when radiation pattern of the base station and radiation pattern of the mobile station are designed to match each other [19], as for the disadvantage of BDMAcan be summarized as follows:

1- Does not support older devices.
2- At the moment the fifth generation technique has not been applied on the ground.
3- BDMA It needs to be qualified engineers for the purpose of operating and maintenance.

7. Application

The idea of BDMA designed to the next generation in (mobile communication). In addition to 5G mobile communication network will be faster than 3G and 4G, it also has the efficiency and ability to revolutionize in many directions such as health care, automotive, production and energy. It also will make it easier transportation to and from wired - wireless connections. In this case installation costs will be reduced and flexibility will be increase [20].

A. E-health: it can take advantage of this application to calculate and monitor the patient's blood pressure as well as to know the pulse rate. His breathing by wearing the devices assigned to the piece. This application enables the patient to reduce costs by allowing patients to stay out and away from the care facilities [21].

B. Transportation routes: the usefulness of this application to participate in the car with other cars with information on what comes in ways greater efficiency and a very large safety.

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C. Smart train can be more pleasant as travelers travelling on higher speed trains through the vast areas and uninhabited, full 5Gnetwork can work.

D. at densely packed crowd, at an event of sport for example, enhanced the speed and capacity can be Increases entertainment due to the Increases of the virtual reality close to the truth.

E. It is possible to get a revolution in Industry and manufacturing due to the Fifth-generation technologies. Where the robots of factories will depend on 5G in many aspects of the work, this will increase production and reduce the cost[22].

F. In CGCS (complementary ground component) it is ought to reuse frequencies between (satellite) and (CGC) components under allowable interference level [23].

8- CONCLUSION

In this paper we have surveyed 5G wireless technology phones. Like the 5G BDMA-based technology that provides the best quality of service. And at the lowest cost to serve a greater number of connections to the number of users without quality within the limited spectrum available loss with increased system capacity. There are a lot of enchantment from 1G to 5G wireless technology. BDMA is the latest technology used in the next generation. Some new technologies has been added to wireless networks 5G, This makes the 5G wireless network is more high-end than the 4G network, and more technical. It 5G will cover the world and offers seamless service as its basic goal Like the 5G BDMA-based technology that provides the best quality of service. And at the lowest cost to serve a greater number of connections to the number of users without quality within the limited spectrum available loss with increased system capacity compare with the. Also 5G will achieve its goals through the efficient use of spectrum, dynamic allocation of broadband, transmission technology upgrades and other aspects. Where we can say that a full update for 3G and 4G. Can 5G use broadband more efficient to improve the transmission speed and the flow of information within the time unit and have a huge Development on cloud computing, e-commerce, and the wisdom of life related industries The use of (BDMA technology) in the 5G can improve the capacity of system, and thus can increases the coverage of service on larger areas and throughput of system. Compere with 5G millimeter wave technology that supports only LOS (Line of Sight) propagation. Hence coverage is limited to LOS and loss of energy because of higher at millimeter wave due to more number of radio frequency modules due to large number of antennas. In BDMA technique BS transmit different beams with different directions to MS without interference. Compared with Mobile Ad-hoc Networks (MANETs) is the process of guiding the data packets from end to end, where it will be difficult in mobile ad hoc networks because of the continued movement and the absence of centralized control over all nodes (Mobile Station).

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